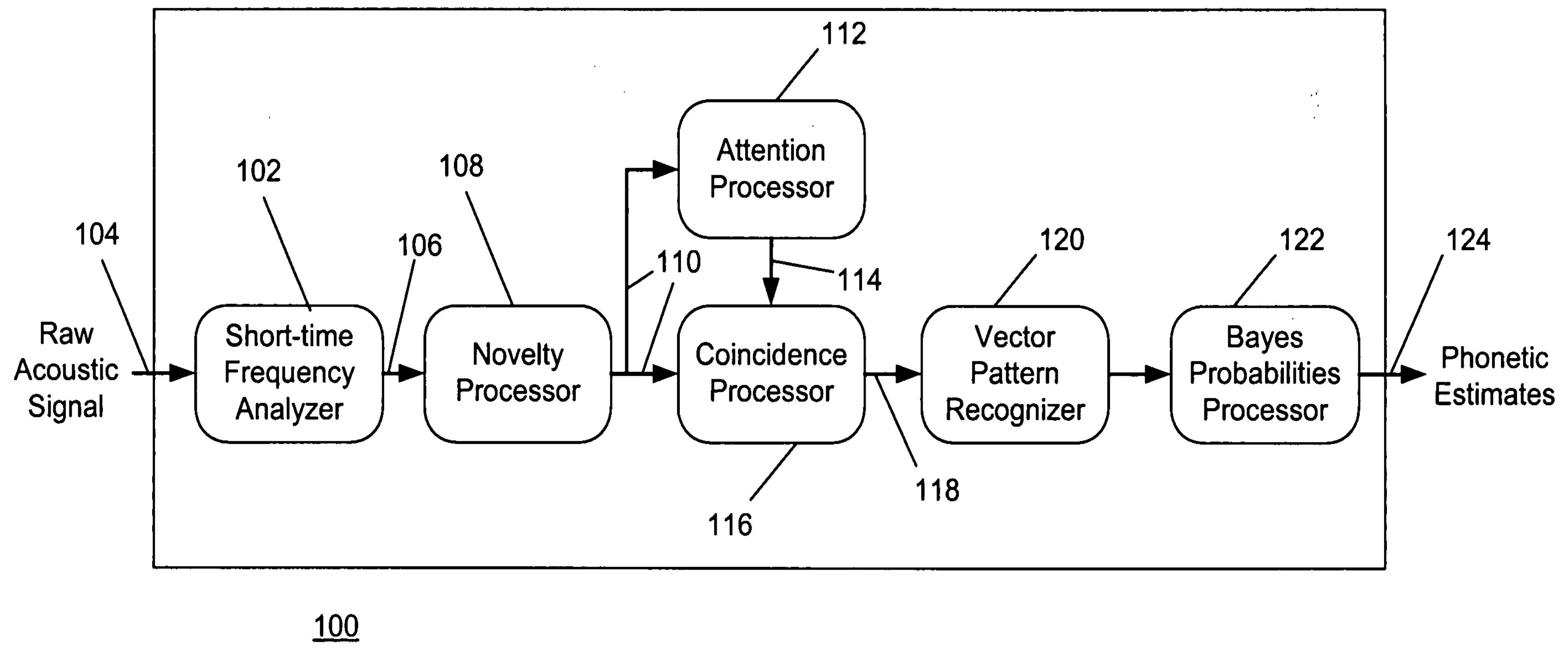

Raw Acoustic Signal
104
102
Short-time Frequency Analyzer
106
108
Novelty Processor
110
112
Attention Processor
114
Coincidence Processor
116
118
120
Vector Pattern Recognizer
122
Bayes Probabilities Processor
124
Phonetic Estimates
100

FIG. 1

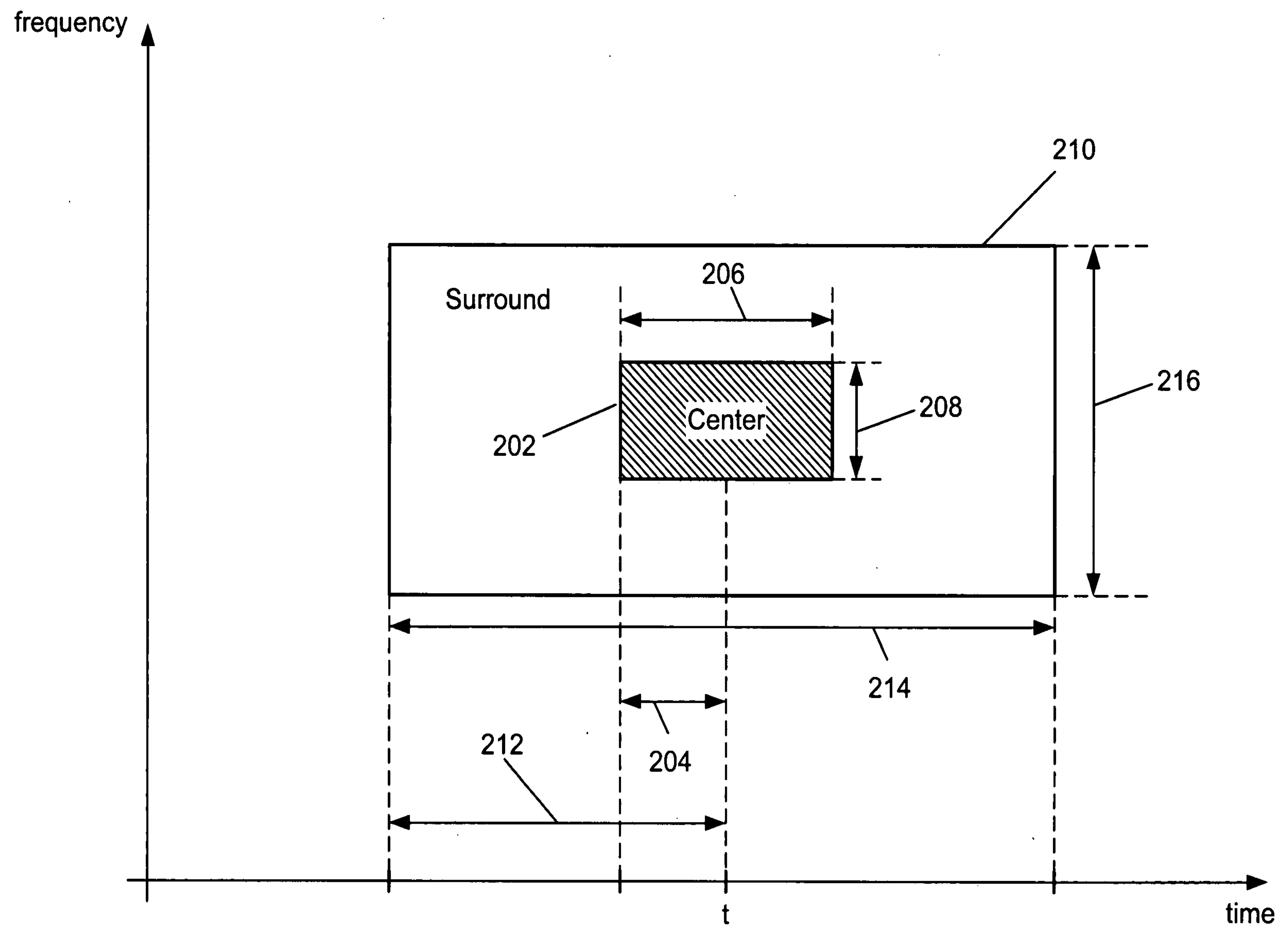
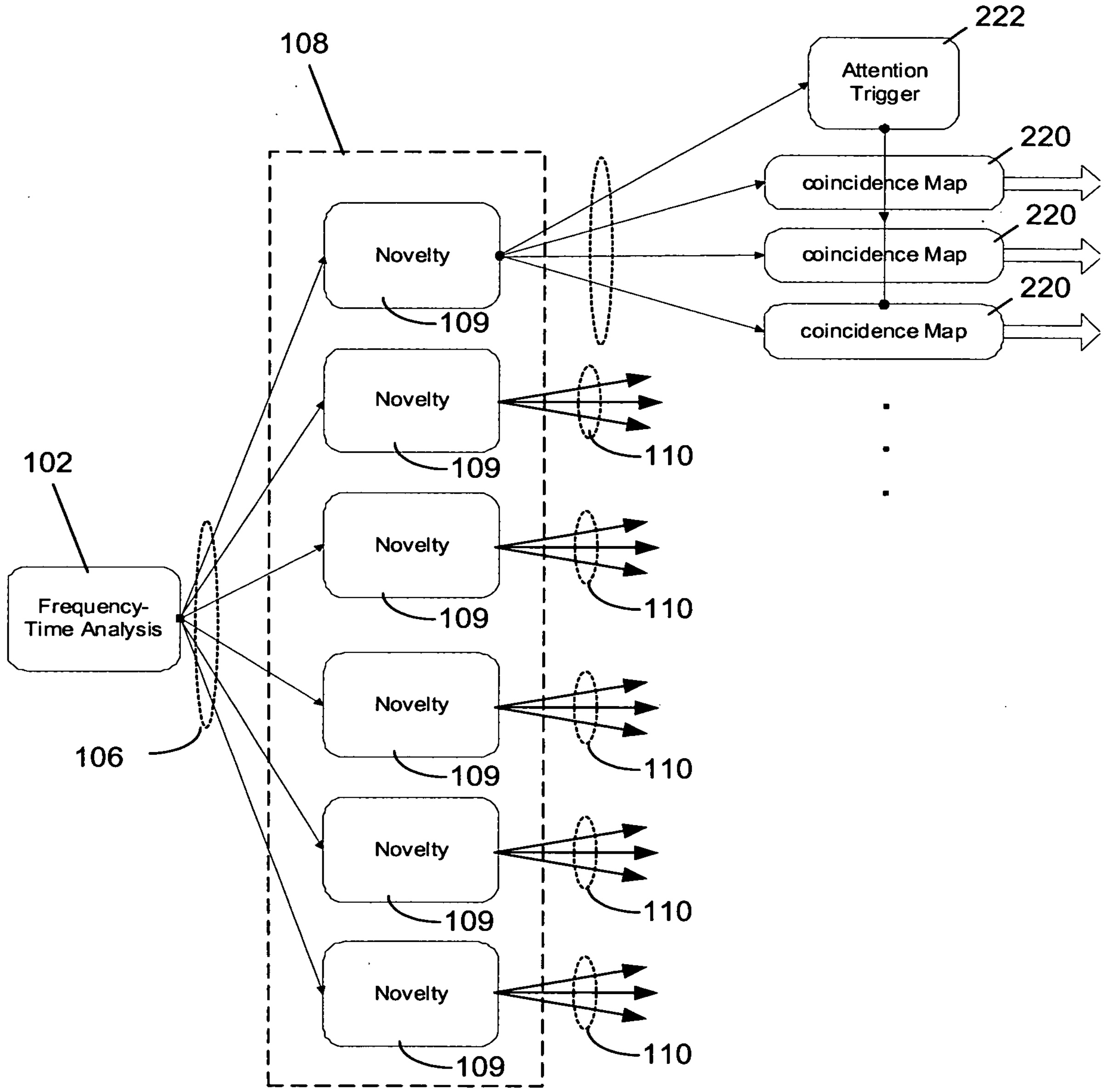

frequency
210
Surround
206
216
208
Center
202
214
204
212
t
time

FIG. 2



222
Attention Trigger
220
coincidence Map
220
coincidence Map
220
coincidence Map
108
Novelty
109
Novelty
109
110
Novelty
109
110
Novelty
109
110
Novelty
109
110
Novelty
109
110
102
Frequency-Time Analysis
106

FIG. 3

FRICATIVES

Novelty Processing

Channel	Center Start	Center Length	Center Width	Alpha	Surround Start	Surround Length	Surround Width
0	10	6	1	0.6	0	all	1
1	4	3	8	0.7	6	8	3
2	0	4	2	0.7	1	8	10
3	1	2	2	1.0	0	all	1
4	10	4	4	0.9	0	all	1
5	0	1	10	1.1	4	2	14

FIG. 4

Coincidence Processing. The output size is 576

Function	Attention Trigger	Delta	Start	Stop	Width	Novelty Channel
eCrossColumn	ePlus	-1	1	12	7	0
eCrossColumn	eMinus	1	0	14	13	2
eCrossColumn	eDeltaMinus	-6	6	24	6	2
eCrossColumn	eDeltaPlus	1	12	23	3	2
eCrossColumn	eDeltaMinus	0	3	24	2	3
eCrossColumn	eDeltaPlusM2	-5	5	24	1	3
eCrossColumn	eMinus	-5	22	24	8	4
eCrossColumn	ePlus	0	8	13	1	4
eCrossColumn	eDeltaPlusP2	-7	7	24	6	5
eCrossColumn	eDeltaPlus	3	0	21	16	5
eCrossColumn	ePlus	-5	8	24	16	5
selfAddLocalFreq	eDeltaMinus		7	24	6	5
selfAddLocalFreq			14	24	10	5
selfAddLocalFreq	eMinus		1	24	5	5
selfAddLocalFreq	eDeltaPlus		1	24	8	2
selfAddLocalFreq	eDeltaMinus		0	22	13	1
selfAddLocalFreq	eMinus		0	7	6	1
selfAddLocalFreq	eDeltaMinus		3	24	11	0
crossAddLocalFreq	eDeltaPlus	2	0	22	9	1
crossAddLocalFreq	eDeltaMinus	3	0	21	15	1
crossAddLocalFreq	eDeltaPlusP2	2	0	22	6	2
crossAddLocalFreq		1	13	23	11	2
crossAddLocalFreq		-3	3	24	5	3
crossAddLocalFreq		-1	1	24	3	3
crossAddLocalFreq	ePlus	-4	4	24	12	5
crossAddLocalFreq	ePlus	3	0	21	11	5
crossAddLocalFreq	eMinus	-2	2	24	11	5

FIG. 5

VOWELS

Novelty processing.

Channel	Center Start	Center Length	Center Width	Alpha	Surround Start	Surround Length	Surround Width
0	6	4	4	0.6	0	8	4
1	0	2	1	1.0	0	all	1
2	4	6	6	0.9	0	all	1
3	8	6	3	0.8	8	16	20
4	0	3	6	1.2	2	4	14
5	4	1	1	0.9	2	4	12

FIG. 6

Coincidence Processing. The output size is 696.

Function	Attention Trigger	Delta	Start	Stop	Width	Novelty Channel
EcrossColumn	ePlus	-7	7	22	9	1
EcrossColumn	eDeltaPlusM2	-2	2	24	5	1
ECrossColumn	ePlus	2	0	21	3	1
ECrossColumn	eMinus	-7	17	21	4	2
ECrossColumn	eDeltaMinus	-4	4	24	13	2
ECrossColumn	eDeltaPlus	-7	7	24	6	3
ECrossColumn		-7	7	12	6	3
ECrossColumn	eMinus	-6	6	24	4	3
ECrossColumn	eDeltaMinus	-2	2	24	10	4
SelfAddLocalFreq	eDeltaPlusP2		5	23	16	4
SelfAddLocalFreq	ePlus		2	24	3	5
SelfAddLocalFreq	eDeltaMinus		6	24	16	5
SelfAddLocalFreq	eDeltaMinus		0	21	16	0
SelfAddLocalFreq			3	24	6	1
SelfAddLocalFreq	ePlus		0	24	9	1
CrossAddLocalFreq		-4	4	24	5	1
CrossAddLocalFreq	eDeltaPlus	-4	4	24	7	1
CrossAddLocalFreq	eDeltaPlus	-3	3	23	5	2
CrossAddLocalFreq	ePlus	2	0	22	7	2
CrossAddLocalFreq	ePlus	-2	2	24	5	3
CrossAddLocalFreq	eMinus	-3	3	24	13	3
CrossAddLocalFreq	eDeltaPlusP2	1	0	23	8	3
CrossAddLocalFreq	eMinus	1	0	23	5	4
CrossAddLocalFreq	eDeltaPlus	-2	2	24	6	4
CrossAddLocalFreq	ePlus	-2	2	24	4	5
CrossAddLocalFreq	eMinus	-3	3	24	9	5

FIG. 7

NONFRICATIVES

Novelty Processing.

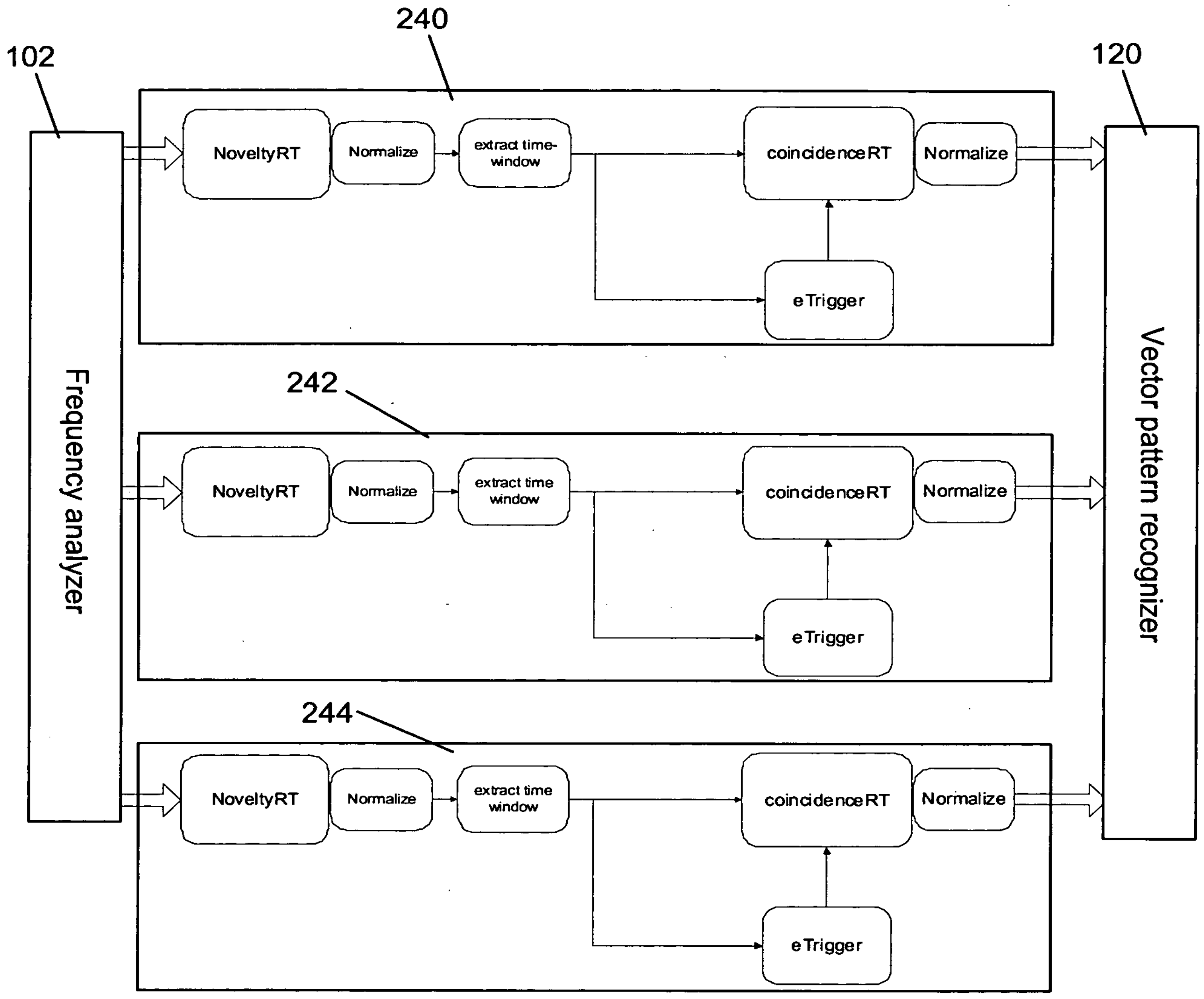
Channel	Center Start	Center Length	Center Width	Alpha	Surround Start	Surround Length	Surround Width
0	4	4	1	1.0	3	2	3
1	4	4	8	0.6	0	All	1
2	0	2	1	1.1	0	3	10
3	6	6	4	0.7	0	All	1
4	1	2	2	0.6	0	All	1
5	1	4	6	1.2	10	20	8

FIG. 8

Coincidence Processing. The output size is 697.

Function	**Attention Trigger**	**Delta**	**Start**	**Stop**	**Width**	**Novelty Channel**
eCrossColumn	eDeltaPlus	-7	7	16	10	0
eCrossColumn	eMinus	0	0	23	10	0
eCrossColumn		-2	2	24	4	0
eCrossColumn	ePlus	-7	7	17	6	1
eCrossColumn	eDeltaPlus	-1	14	24	10	1
eCrossColumn	eDeltaPlus	1	0	23	2	2
eCrossColumn	eDeltaMinus	0	0	24	4	2
eCrossColumn	eDeltaPlus	-1	1	24	13	2
eCrossColumn	ePlus	2	0	18	10	4
eCrossColumn	eMinus	-5	10	24	5	5
selfAddLocalFreq	ePlus		4	18	17	0
selfAddLocalFreq	eDeltaMinus		0	24	5	0
selfAddLocalFreq	eDeltaPlusM2		5	23	6	1
selfAddLocalFreq			1	24	4	2
crossAddLocalFreq	eMinus	3	0	21	5	0
crossAddLocalFreq	ePlus	-2	2	24	12	0
crossAddLocalFreq		-4	4	24	6	2
crossAddLocalFreq		1	0	23	5	2
crossAddLocalFreq		-2	2	24	5	3
crossAddLocalFreq	eDeltaPlus	1	0	23	6	4
crossAddLocalFreq		-4	4	24	9	4
crossAddLocalFreq		-7	7	24	8	4
crossAddLocalFreq	eDeltaPlus	-2	2	24	3	4
crossAddLocalFreq	eDeltaPlusP2	-3	3	24	10	4
crossAddLocalFreq		-6	6	24	13	5
crossAddLocalFreq	eDeltaPlus	2	9	22	13	5

FIG. 9



240
102
120
242
244
Frequency analyzer
Vector pattern recognizer
NoveltyRT
Normalize
extract time-window
coincidenceRT
Normalize
eTrigger
NoveltyRT
Normalize
extract time window
coincidenceRT
Normalize
eTrigger
NoveltyRT
Normalize
extract time window
coincidenceRT
Normalize
eTrigger

FIG. 10

```
!
! Default signal flow is from one line to the next.
! The general syntax is:
!       input1:, input2: ---> processName ---> output: with/from/to parameter-list
!
            putinmaxflo --->
        ---> mu_lawRT ---> mu:
mu:     ---> procrustes ---> spf:       with    192 192
mu:     ---> echocancel ---> input:     with    cancel 1
input:  ---> chunkify  --->     with    128 32
        ---> remove_mean ---> rem:
        ---> mv_multiply ---> dft:      with    Four4_57.tab
        ---> cvpower    ---> cvp:
cvp:   ---> procrustes --->     with    1 54
        ---> record_stats ---> eng:     with    sum no_normalize
cvp:   ---> hanning    ---> han:
        ---> procrustes --->    with    1 54
        ---> compress   ---> c: with  normalize 1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1
1 1 1  2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 -1
eng: ,c: ---> concatenate --->
        ---> log2       ---> log40:     with    1.0

log40:  ---> noveltyRT -->              with    vowels
     ---> normalize  --->         with          no mu1vowels.log40 si1vowels.log40
,eng: ---> zeroOnLow --->               with 0.0
     ---> extract ---> ev:              with   3 24 12
ev:    ---> eTrigger  ---> tv:          with   6 24 41
ev:, tv:  ---> coincidenceRT --->       with   6 24 41 vowels
        ---> normalize  ---> v:         with    no muvowels.p4 sivowels.p4

log40:  ---> noveltyRT -->              with    fricatives
     ---> normalize  --->         with          no mu1fricatives.log40 si1fricatives.log40
,eng: ---> zeroOnLow --->               with 0.0
     ---> extract ---> ef:              with   3 24 12
ef:    ---> eTrigger  ---> tf:          with   6 24 41
ef:, tf:  ---> coincidenceRT --->       with   6 24 41 fricatives
        ---> normalize  ---> f:         with    no mufricatives.p4 sifricatives.p4

log40:  ---> noveltyRT -->              with    nonfricatives
     ---> normalize  --->         with  no mu1nonfricatives.log40 si1nonfricatives.log40
,eng: ---> zeroOnLow --->               with 0.0
     ---> extract ---> en:              with   3 24 12
en:    ---> eTrigger  ---> tn:          with   6 24 41
en:, tn:  ---> coincidenceRT --->       with   6 24 41 nonfricatives
        ---> normalize  ---> nf:        with    no munonfricatives.p4 sinonfricatives.p4
```

FIG. 11A

```
v:, f:  ---> concatenate --->
 , nf:  ---> concatenate --->
          ---> mean_square_norm ---> ms:     with    yes yes
ms:      ---> mv_multiply --->          with    k.GA
          ---> map  --->                with    npllr.GA
          ---> nBest ---> best:         with    7

eng:      ---> extract --->             with    3 24 23
          ---> record_stats ---> eLong: with    sum normalize

eLong:          ---> log2 --->                  with    1.0
,best:          ---> scale ---> ebest:          with    long 1000.0 200.0
spf:            ---> delay -->                  with    11
                ---> extract --->               with    3 1 0
                ---> scale ---> sps:            with    long
sps:,ebest:     ---> concatenate --->
                ---> putoutAS
                     stop
```

FIG. 11B

List of Processes

chunkify	- aggregates the sound data stream into overlapping segments
coincidenceRT	- see main text
compress	- aggregates each data vector into the given bins by averaging over bin
concatenate	- concatenates each pair of incoming vectors into one output vector
cvpower	- computes power spectrum from complex DFT spectrum
delay	- delays a data stream
eTrigger	- see main text
echocancel	- performs echocancelling using voice in and voice out streams
extract	- extracts a time window of specified width and decimation
hanning	- standard hanning filter
log2	- log base2
map	- applies a nonlinear, pointwise transform as specified by control file
mean_square_norm	- normalizes each vector by mean and standard deviation
mu_lawRT	- inverse mu-law
mv_multiply	- matrix-vector multiply
nBest	- zeros out all but the N highest elements of a vector
normalize	- subtracts constant mean vector, and divides by a constant scale vector
noveltyRT	- see main text
putinmaxflo	- provides input data stream from system
putoutAS	- accepts output phonetic stream to pass on to rest of system
record_stats	- computes mean and sigma for each vector
remove_mean	- subtracts the vector mean from each vector
procrustes	- selects a contiguous central portion of a vector
zeroOnLow	- zeros a vector according to empirical low energy condition

Parameter Files

Four4_57.tab	- Fourier coefficient matrix
k.GA	- matrix of phonetic vector-coefficients
mu1fricatives.log40	- constant mean vector
mu1nonfricatives.log40	- constant mean vector
mu1vowels.log40	- constant mean vector
mufricatives.p4	- constant mean vector
munonfricatives.p4	- constant mean vector
muvowels.p4	- constant mean vector
npllr.GA	- specifies nonlinear transform to create log-likelihood ratio output
si1fricatives.log40	- constant scale vector
si1nonfricatives.log40	- constant scale vector
si1vowels.log40	- constant scale vector
sifricatives.p4	- constant scale vector
sinonfricatives.p4	- constant scale vector
sivowels.p4	- constant scale vector

FIG. 12

The ScaleMean object as referenced by normalizeRT.

```
#include "StdAfx.h"
#include <stdlib.h>
#include <stdio.h>
#include <assert.h>
#include <math.h>


#define MAX_MEM 100

class ScaleMean
{
        Zbuffer *buf0;
        int start;
        int length;
        int width;
        int numberInBuf0;
        float* fInTime[ MAX_MEM ];

public:
        ScaleMean();
        float get( int i );
        void init( Zipper* aZipper, int aStart, int aLength, int aWidth);
        void update( Zipper* z1 );
        float sides( Zipper* z1, int i );
};


ScaleMean::ScaleMean()
{
        buf0 = NULL;
}

void ScaleMean::init( Zipper* aZipper, int aStart, int aLength, int aWidth)
{
        start = aStart;
        length = aLength;
        width = aWidth;
        numberInBuf0 = 0;
        if ( buf0 == NULL )
                buf0 = new Zbuffer ( "buf0", aZipper->getType(), aZipper->getSize(),
start+length );
        else
                buf0->zero();
}
```

FIG. 13A

```
float ScaleMean::sides( Zipper* z1, int i )
{
        float sidesSum = (float) 0.0;
        float sidesMean;
        float* pf = (float*) z1->getData();

        // Energy has no sides
        if ( i == 0 )
                return pf[0];

        int n = 0;
        int size = (int) z1->getSize();
        // Add in sides where possible.
        int f = max( 1, i - width );
        int fEnd = min( size-1, i + width );
        while ( f <= fEnd ) {
                sidesSum += pf[f++];
                n++;
        }

        sidesMean = (float) quo( sidesSum, ( float ) n );
        return sidesMean;
}

void ScaleMean::update( Zipper* z1 )
{
        buf0->update();

        Zipper* z0 = buf0->get( buf0->getLength()-1 );
        float *pf = (float*) z0->getData();
        for ( long i = 0; i < (long) z1->getSize(); i++ ) {
                pf[i] = sides( z1, i );
        }
        if (numberInBuf0 < (int) buf0->getLength()) numberInBuf0++;
        int len = buf0->getLength();
        for (int j = 0; j < len; j++ )
        {       // Find the time in the past.
                Zipper *pz0 = buf0->get(len - 1 - j );
                fInTime[ j ] = ( float* ) pz0->getData();
        }
}
```

FIG. 13B

```
float ScaleMean::get( int i )
{
        float scaleSum = (float) 0.0;
        float scaleMean;

        // Just average over the ones we actually have.
        float n = 0.0;
        for ( int j = start; j < numberInBuf0; j++ ) {
                float* fIn = fInTime[j];
                scaleSum += fIn[i];
                n++;
                }
        scaleMean = (float) quo( scaleSum, n );
        return scaleMean;
}
```

FIG. 13C

The NoveltyRT process. See Attachment 2 for the definition of the ScaleMean object.

```
 Usage -
        data:,speaking: ---> NoveltyRT ---> with  whichLabelset

*/
#include "StdAfx.h"
#include <stdlib.h>
#include <stdio.h>
#include <assert.h>
#include <math.h>

#include "speedObject.h"
#include "scalemean.h"

#define MAX_SCALES 10

class NoveltyRT : public SpeedProcess
{
public:
        NoveltyRT();
        ~NoveltyRT();

        int begin ();
        int beginFile(Zipper* z1, Zipper* z2 );
        Zipper* processZipper( Zipper* z1, Zipper* z2 );
        Zipper* finalFileZipper ();

        void accumMeanAllTime();
        float getScaleMeanAllTime( int i );

        void universal( int size, ScaleMean* center, ScaleMean* surround, double alpha );

private:
        Zbuffer *buf0;

        int numberOfScales;
        int outSize;
        int whichFlavor;
        BOOL bSpeaking;

        ScaleMean* cScales[ MAX_SCALES ];
        ScaleMean* sScales[ MAX_SCALES ];
        double alpha[ MAX_SCALES ];

        Zbuffer *allTimeSum;
```

FIG. 14A

```
Zipper* pZallTimeSum;
        float allTimeCount;

        int iout;
        Zipper* theZout;
        void put( double x ) { theZout->put( iout++, x ); };
};


NoveltyRT::NoveltyRT() : SpeedProcess( "NoveltyRT" )
{
        allTimeSum = NULL;
        buf0 = NULL;
}

NoveltyRT::~NoveltyRT()
{
        delete allTimeSum;
}

/* NoveltyRT - called from initNet() in netnode.cpp
 * whenever a node is created for this process.
 */
SpeedObject* noveltyRT()
{
        return (new NoveltyRT);
}

int NoveltyRT::begin ()
{
        whichFlavor = (int) parameters->askWords( "fricatives nonfricatives vowels" );
        allTimeSum = NULL;
        buf0 = NULL;
        for ( int i=0; i < MAX_SCALES; i++ ) {
                cScales[i] = NULL;
                sScales[i] = NULL;
        }
        return TRUE;
}

Zipper* NoveltyRT::finalFileZipper ()
{
        cout << "Spectrum for Transaction:" << endl;
        if ( allTimeCount > 0 )
                for ( int i = 0; i < pZallTimeSum->getSize(); i++ )
                        cout << pZallTimeSum->get(i)/allTimeCount << " ";
```

FIG. 14B

```
cout << endl;

        dataState = BUF_EOT;
        return NULL;
}

int NoveltyRT::beginFile(Zipper* z1, Zipper* z2)
{
        assert( z1->getType() == ELIZA_FLOAT );
        for ( int i=0; i < MAX_SCALES; i++ ) {
                delete cScales[i];
                delete sScales[i];
                cScales[i] = NULL;
                sScales[i] = NULL;
        }


        // FRICATIVES
        if ( whichFlavor == 0 ) {
                numberOfScales = 6;
                cScales[0] = new ScaleMean();
                cScales[0]->init( z1, 10, 6, 1 );
                sScales[0] = NULL;
                alpha[0] = 0.6;

                cScales[1] = new ScaleMean();
                cScales[1]->init( z1, 4, 3, 8 );
                sScales[1] = new ScaleMean();
                sScales[1]->init( z1, 6, 8, 3 );
                alpha[1] = 0.7;

                cScales[2] = new ScaleMean();
                cScales[2]->init( z1, 0, 4, 2 );
                sScales[2] = new ScaleMean();
                sScales[2]->init( z1, 1, 8, 10 );
                alpha[2] = 0.7;

                cScales[3] = new ScaleMean();
                cScales[3]->init( z1, 1, 2, 2 );
                sScales[3] = NULL;
                alpha[3] = 1.0;

                cScales[4] = new ScaleMean();
                cScales[4]->init( z1, 10, 4, 4 );
                sScales[4] = NULL;
                alpha[4] = 0.9;
```

FIG. 14C

```
        cScales[5] = new ScaleMean();
        cScales[5]->init( z1, 0, 1, 10 );
        sScales[5] = new ScaleMean();
        sScales[5]->init( z1, 4, 2, 14 );
        alpha[5] = 1.1;
}

// VOWELS
else if ( whichFlavor == 2 ) {
        numberOfScales = 6;

        cScales[0] = new ScaleMean();
        cScales[0]->init( z1, 6, 4, 4);
        sScales[0] = new ScaleMean();
        sScales[0]->init( z1, 0, 8, 4);
        alpha[0] = 0.6;

        cScales[1] = new ScaleMean();
        cScales[1]->init( z1, 0, 2, 1 );
        sScales[1] =NULL;
        alpha[1] = 1.0;

        cScales[2] = new ScaleMean();
        cScales[2]->init( z1, 4, 6, 6 );
        sScales[2] = NULL;
        alpha[2] = 0.9;

        cScales[3] = new ScaleMean();
        cScales[3]->init( z1, 8, 6, 3 );
        sScales[3] = new ScaleMean();
        sScales[3]->init( z1, 8, 16, 20 );
        alpha[3] = 0.8;

        cScales[4] = new ScaleMean();
        cScales[4]->init( z1, 0, 3, 6 );
        sScales[4] = new ScaleMean();
        sScales[4]->init( z1, 2, 4, 14 );
        alpha[4] = 1.2;

        cScales[5] = new ScaleMean();
        cScales[5]->init( z1, 4, 1, 1 );
        sScales[5] = new ScaleMean();
        sScales[5]->init( z1, 2, 4, 12 );
        alpha[5] = 0.9;
}
```

FIG. 14D

```
//NONFRICATIVES
        else if ( whichFlavor == 1 ) {
                numberOfScales = 6;

                cScales[0] = new ScaleMean();
                cScales[0]->init( z1, 4, 4, 1 );
                sScales[0] = new ScaleMean();
                sScales[0]->init( z1, 3, 2, 3 );
                alpha[0] = 1.0;

                cScales[1] = new ScaleMean();
                cScales[1]->init( z1, 4, 4, 8 );
                sScales[1] = NULL;
                alpha[1] = 0.6;

                cScales[2] = new ScaleMean();
                cScales[2]->init( z1, 0, 2, 1 );
                sScales[2] = new ScaleMean();
                sScales[2]->init( z1, 0, 3, 10 );
                alpha[2] = 1.1;

                cScales[3] = new ScaleMean();
                cScales[3]->init( z1, 6, 6, 4 );
                sScales[3] = NULL;
                alpha[3] = 0.7;

                cScales[4] = new ScaleMean();
                cScales[4]->init( z1, 1, 2, 2 );
                sScales[4] = NULL;
                alpha[4] = 0.6;

                cScales[5] = new ScaleMean();
                cScales[5]->init( z1, 1, 4, 6 );
                sScales[5] = new ScaleMean();
                sScales[5]->init( z1, 10, 20, 8 );
                alpha[5] = 1.2;
        }

        allTimeCount = (float) 0.0;
        outSize = z1->getSize() * numberOfScales;

        if ( buf0 == NULL )
        {
                // We need a min of 3 for finding energy in accumMeanAllTime.
                buf0 = new Zbuffer ( "buf0", z1->getType(), z1->getSize(), 3 );
```

FIG. 14E

```
                allTimeSum = new Zbuffer( "allTimeSum", z1->getType(), z1->getSize(), 1
);
                pZallTimeSum = allTimeSum->get( 0 );

        }
        else
                allTimeSum->zero();

        return TRUE;
}

/* Returns the mean for all time in this file.
 */
void NoveltyRT::accumMeanAllTime()
{
        // Get average of energy AROUND time 1.
        float energy = (float) 0.0;
        for (int i = 0; i < 3; i++)
                energy += (float) buf0->get(i)->get(0);
        energy = (float) (energy / 3.0);

        /* Check fixed energy threshold. */
        if (energy > 22)
        {
                float *pfSum = (float*) pZallTimeSum->getData();
                allTimeCount++;
                for ( i = 0; i < (int) pZallTimeSum->getSize(); i++ )
                {
                        float newVal = (float) buf0->get(1)->get(i);
                        pfSum[i] += newVal;
                }
        }

        return;
}

float NoveltyRT::getScaleMeanAllTime( int i )
{
        float scaleSum = (float ) pZallTimeSum->get( i );
        return (float) quo( scaleSum, allTimeCount );
}

Zipper* NoveltyRT::processZipper(Zipper* z1, Zipper* z2)
{
        Zipper* zout = Zipper::createZipper( ELIZA_FLOAT, outSize );
        zout->zero();
```

FIG. 14F

```
        bSpeaking = FALSE;
        if(z2) bSpeaking = int(z2->get(0));
        // Store the input data in memory.
        buf0->put( z1 );
        if(bSpeaking) {

        } else
                accumMeanAllTime();

        // compute the multiscale NoveltyRT for each input point.
        iout = 0;
        theZout = zout;

        for (int b = 0; b < numberOfScales; b++) {
                if ( cScales[b] != NULL )
                        cScales[b]->update( z1 );
                if ( sScales[b] != NULL )
                        sScales[b]->update( z1 );
                universal( z1->getSize(), cScales[b], sScales[b], alpha[b] );
                }
        return zout;
}

void NoveltyRT::universal( int size, ScaleMean* center, ScaleMean* surround, double
alpha )
{
        double scaleMean, scaleMean2, theNovelty;

        if ( surround == NULL ) {
                for (int i = 0; i < size; i++ ) {
                        scaleMean  = center->get( i );
                        scaleMean2 = getScaleMeanAllTime( i );
                        theNovelty = scaleMean - alpha * scaleMean2;
                        put( theNovelty );
                }
        }
        else {
                for (int i = 0; i < size; i++ ) {
                        scaleMean  = center->get( i );
                        scaleMean2 = surround->get( i );
                        theNovelty = scaleMean - alpha * scaleMean2;
                        put( theNovelty );
                }
        }
}
```

FIG. 14G

```
Usage -
                 ---> coincidenceRT --->    with   name0 | name1 | etc.

 Function -

 */
#include "StdAfx.h"
#include <stdlib.h>
#include <stdio.h>
#include <string.h>
#include <assert.h>
#include <math.h>

#include "speedObject.h"
#include "eTrigger.h"

class CoincidenceRT : public SpeedProcess
{
public:
        CoincidenceRT();
        ~CoincidenceRT();

        int begin ();
        int beginFile(Zipper* z1, Zipper* z2);
        int final();
        Zipper* processZipper (Zipper*, Zipper*);
        double get( int t, int f, int offset )
        {
                if ( t < 0 )
                        return 0.0;
                else
                        return pin[ t * inputStride + offset + f ];
        }

public:
        int numberOfScales;
        int numberOfTimes;
        int gateStride;
        int columnSize;
        int localFreqSize;

private:
        int whichProcess;
        BOOL countMode;
        BOOL bSetSize;
```

FIG. 15A

```
int nTotal;
        int inputStride;
        int deltaWidth;
        int deltaStep;
        float *pin;
        char* pGate;
        float *pout;

        float* getAddr( int t, int f, int offset ) {
                return pin + (t * inputStride + offset + f);
        }

        void put( double x ) {
                if ( countMode )
                        nTotal++;
                else
                        *pout++ = (float) x;
        }
        void doFricatives2();
        void doNonFricatives2();
        void doVowels2();
        void doGA();
        void doNonFricatives();
        void doVowels();
        void doFricatives();
        void dispatch();

        void eCrossColumn( int delta, int tstart, int tstop, int fWidth, int whichScale);
        void eCrossColumn( eGateType eGate, int delta, int tstart, int tstop, int fWidth, int
whichScale );

        void selfAddLocalFreq(       int tstart, int tstop, int localN, int whichScale );
        void selfAddLocalFreq( eGateType eGate, int tstart, int tstop, int localN, int
whichScale );

        void crossAddLocalFreq( int delta, int tstart, int tstop, int fWidth, int whichScale );
        void crossAddLocalFreq( eGateType eGate, int delta, int tstart, int tstop, int
fWidth, int whichScale );
};

int CoincidenceRT::begin()
{
        deltaWidth = localFreqSize = 4;
        deltaStep = 1;
        numberOfScales = (int) parameters->AskUser("Number of scales from novelty",
0.0, 10.0, 10.0 );
```

FIG. 15B

```
        numberOfTimes = (int) parameters->AskUser("Number of times in RF", 0.0,
100.0, 100.0 );
        gateStride = numberOfTimes * numberOfScales;
        localFreqSize = (int) parameters->AskUser("Local Frequency Size", 0.0, 100.0,
100.0 );
        whichProcess = parameters->askWords("GA nonfricatives vowels fricatives");
        bSetSize = TRUE;
        return TRUE;
}
void CoincidenceRT::dispatch()
{
        switch (whichProcess) {
                case 0:
                        doGA();
                        break;
                case 1:
                        doNonFricatives();
                        break;
                case 2:
                        doVowels();
                        break;
                case 3:
                        doFricatives();
                        break;
                }
}

int CoincidenceRT::beginFile(Zipper* z1, Zipper* z2)
{
        // Simulate one run in countMode
        pin = (float *) z1->getData();
        pGate = (char *) z2->getData();
        if (bSetSize)
        {
                columnSize = z1->getSize() / ( numberOfScales * numberOfTimes );
                inputStride = numberOfScales * columnSize;

                nTotal = 0;
                countMode = TRUE;
                dispatch();
                countMode = FALSE;
                int nf = columnSize-1;
                int nfl = nf / localFreqSize;
                bSetSize = FALSE;
                cout << "CoincidenceRT: stride " << inputStride;
                cout << " columnSize " << columnSize;
```

FIG. 15C

```
                //cout << " nfl is " << nfl << " nTotal = " << nTotal;
                cout << endl;
        }
        return TRUE;
}

Zipper* CoincidenceRT::processZipper (Zipper* z1, Zipper* z2)
{
        pin = (float *) z1->getData();
        pGate = (char *) z2->getData();
        Zipper* zOut = Zipper::createZipper( ELIZA_FLOAT, nTotal );
        zOut->zero();
        pout = (float *) zOut->getData();

        //dist->increment( ehi[1] - ehi[0]);
        dispatch();
        return zOut;
}

void CoincidenceRT::doFricatives()
{
        //output size is 576
        eCrossColumn( ePlus,        -1,  1,  12,   7, 0 );
        eCrossColumn( eMinus,        1,  0,  14,  13, 2 );
        eCrossColumn( eDeltaMinus,  -6,  6,  24,   6, 2 );
        eCrossColumn( eDeltaPlus,    1, 12,  23,   3, 2 );
        eCrossColumn( eDeltaMinus,   0,  3,  24,   2, 3 );
        eCrossColumn( eDeltaPlusM2, -5,  5,  24,   1, 3 );
        eCrossColumn( eMinus,       -5, 22,  24,   8, 4 );
        eCrossColumn( ePlus,         0,  8,  13,   1, 4 );
        eCrossColumn( eDeltaPlusP2, -7,  7,  24,   6, 5 );
        eCrossColumn( eDeltaPlus,    3,  0,  21,  16, 5 );
        eCrossColumn( ePlus,        -5,  8,  24,  16, 5 );
        selfAddLocalFreO( eDeltaMinus,    7,  24,   6, 5 );
        selfAddLocalFreq(                                 14,  24,  10, 5 );
        selfAddLocalFreO( eMinus,         1,  24,   5, 5 );
        selfAddLocalFreO( eDeltaPlus,     1,  24,   8, 2 );
        selfAddLocalFreO( eDeltaMinus,    0,  22,  13, 1 );
        selfAddLocalFreO( eMinus,         0,   7,   6, 1 );
        selfAddLocalFreO( eDeltaMinus,    3,  24,  11, 0 );
        crossAddLocalFreO( eDeltaPlus,    2,   0,  22,   9, 1 );
        crossAddLocalFreO( eDeltaMinus,   3,   0,  21,  15, 1 );
        crossAddLocalFreO( eDeltaPlusP2,  2,   0,  22,   6, 2 );
        crossAddLocalFreO(                1,  13,  23,  11, 2 );
        crossAddLocalFreO(               -3,   3,  24,   5, 3 );
        crossAddLocalFreO(               -1,   1,  24,   3, 3 );
```

FIG. 15D

```
        crossAddLocalFreO( ePlus,       -4,  4,  24,  12, 5 );
        crossAddLocalFreO( ePlus,        3,  0,  21,  11, 5 );
        crossAddLocalFreO( eMinus,      -2,  2,  24,  11, 5 );
}

void CoincidenceRT::doNonFricatives()
{
        //output size is 697
        eCrossColumn( eDeltaPlus,   -7,  7,  16,  10, 0 );
        eCrossColumn( eMinus,        0,  0,  23,  10, 0 );
        eCrossColumn(               -2,  2,  24,   4, 0 );
        eCrossColumn( ePlus,        -7,  7,  17,   6, 1 );
        eCrossColumn( eDeltaPlus,   -1, 14,  24,  10, 1 );
        eCrossColumn( eDeltaPlus,    1,  0,  23,   2, 2 );
        eCrossColumn( eDeltaMinus,   0,  0,  24,   4, 2 );
        eCrossColumn( eDeltaPlus,   -1,  1,  24,  13, 2 );
        eCrossColumn( ePlus,         2,  0,  18,  10, 4 );
        eCrossColumn( eMinus,       -5, 10,  24,   5, 5 );
        selfAddLocalFreO( ePlus,         4, 18,  17, 0 );
        selfAddLocalFreO( eDeltaMinus,   0, 24,   5, 0 );
        selfAddLocalFreO( eDeltaPlusM2,  5, 23,   6, 1 );
        selfAddLocalFreq(                1, 24,   4, 2 );
        crossAddLocalFreO( eMinus,       3,  0,  21,   5, 0 );
        crossAddLocalFreq( ePlus,       -2,  2,  24,  12, 0 );
        crossAddLocalFreO(              -4,  4,  24,   6, 2 );
        crossAddLocalFreO(               1,  0,  23,   5, 2 );
        crossAddLocalFreO(              -2,  2,  24,   5, 3 );
        crossAddLocalFreO( eDeltaPlus,   1,  0,  23,   6, 4 );
        crossAddLocalFreO(              -4,  4,  24,   9, 4 );
        crossAddLocalFreO(              -7,  7,  24,   8, 4 );
        crossAddLocalFreO( eDeltaPlus,  -2,  2,  24,   3, 4 );
        crossAddLocalFreq( eDeltaPlusP2, -3,  3,  24,  10, 4 );
        crossAddLocalFreq(              -6,  6,  24,  13, 5 );
        crossAddLocalFreq( eDeltaPlus,   2,  9,  22,  13, 5 );
}

void CoincidenceRT::doVowels()
{
        //output size is 696
        eCrossColumn( ePlus,        -7,  7,  22,   9, 1 );
        eCrossColumn( eDeltaPlusM2, -2,  2,  24,   5, 1 );
        eCrossColumn( ePlus,         2,  0,  21,   3, 1 );
        eCrossColumn( eMinus,       -7, 17,  21,   4, 2 );
        eCrossColumn( eDeltaMinus,  -4,  4,  24,  13, 2 );
        eCrossColumn( eDeltaPlus,   -7,  7,  24,   6, 3 );
        eCrossColumn(               -7,  7,  12,   6, 3 );
```

FIG. 15E

```
        eCrossColumn( eMinus,      -6,  6, 24,  4, 3 );
        eCrossColumn( eDeltaMinus, -2,  2, 24, 10, 4 );
        selfAddLocalFreO( eDeltaPlusP2,  5, 23, 16, 4 );
        selfAddLocalFreO( ePlus,         2, 24,  3, 5 );
        selfAddLocalFreO( eDeltaMinus,   6, 24, 16, 5 );
        selfAddLocalFreO( eDeltaMinus,   0, 21, 16, 0 );
        selfAddLocalFreq(                3, 24,  6, 1 );
        selfAddLocalFreO( ePlus,         0, 24,  9, 1 );
        crossAddLocalFreO(              -4,  4, 24,  5, 1 );
        crossAddLocalFreO( eDeltaPlus,  -4,  4, 24,  7, 1 );
        crossAddLocalFreO( eDeltaPlus,  -3,  3, 23,  5, 2 );
        crossAddLocalFreO( ePlus,        2,  0, 22,  7, 2 );
        crossAddLocalFreO( ePlus,       -2,  2, 24,  5, 3 );
        crossAddLocalFreO( eMinus,      -3,  3, 24, 13, 3 );
        crossAddLocalFreO( eDeltaPlusP2, 1,  0, 23,  8, 3 );
        crossAddLocalFreO( eMinus,       1,  0, 23,  5, 4 );
        crossAddLocalFreO( eDeltaPlus,  -2,  2, 24,  6, 4 );
        crossAddLocalFreO( ePlus,       -2,  2, 24,  4, 5 );
        crossAddLocalFreO( eMinus,      -3,  3, 24,  9, 5 );
}

void CoincidenceRT::doGA()
{
        //doVowels();
        //doFricatives();
//      doNonFricatives();
}

void CoincidenceRT::eCrossColumn( int delta, int tstart, int tstop, int fWidth, int
whichScale=0 )
{
        int scaleBase = whichScale * columnSize;
        // Energy by itself
        double sum = 0.0;
        for ( int t = tstart; t < tstop; t++ )
                sum += get( t, 0, scaleBase ) * get( t+delta, 0, scaleBase );
        put( sum );

        for ( int f = 1; f <= columnSize-fWidth; f += fWidth )
        {
                sum = 0.0;
                for ( int t = tstart; t < tstop; t++ )
                {
                        float* p1 = getAddr( t, 0, scaleBase );
                        float* p2 = getAddr( t+delta, f, scaleBase );
                        for ( int i = 0; i < fWidth; i++ )
```

FIG. 15F

```
                    sum += *p1 * *p2++;
                    }
                    put( sum );
            }
    }

    // N = 1 + numberOfFreqs/fWidth
    void CoincidenceRT::eCrossColumn( eGateType eGate, int delta, int tstart, int tstop, int
    fWidth, int whichScale=0 )
    {
            int scaleBase = whichScale * columnSize;
            int outOffset = whichScale * numberOfTimes;
            char* eGateA = pGate + gateStride * eGate + outOffset;

            // Energy by itself
            double sum = 0.0;
            int stop = min( numberOfTimes-1-delta, tstop );
            int start = max( 0-delta, tstart);
            for ( int t = start; t < stop; t++ ) {
                    sum += get( t, 0, scaleBase ) * get( t+delta, 0, scaleBase );
            }
            put( sum );

            for ( int f = 1; f <= columnSize-fWidth; f += fWidth )
            {
                    sum = 0.0;
                    for ( int t = start; t < stop; t++ )
                    {
                            if ( eGateA[t] ) {
                                    float* p2 = getAddr( t+delta, f, scaleBase );
                                    for ( int i = 0; i < fWidth; i++ ) {
                                            sum += *p2++;
                                    }
                            }
                    }
                    put( sum );
            }
    }

    void CoincidenceRT::selfAddLocalFreq( int tstart, int tstop, int localN, int whichScale )
            {
            int scaleBase = whichScale * columnSize;

            // Do full self product, but amalgamate by localN
            for ( int f1 = 1; f1 < columnSize-localN; f1 += localN )
                    {
```

FIG. 15G

```
        for ( int f2 = 1; f2 <= f1; f2 += localN )
                {
                double sum = 0.0;
                for ( int t = tstart; t < tstop; t++ )
                        {
                        float* p1 = getAddr( t, f1, scaleBase );
                        float* p2 = getAddr( t, f2, scaleBase );
                        for ( int i = 0; i < localN; i++ )
                                sum += *p1++ * *p2++;
                        }
                put( quo( sum, tstop - tstart ) );
                }
        }
    }

// N = ( numberOfFreqs / localN ) * ( numberOfFreqs / localN - 1 ) / 2
void CoincidenceRT::selfAddLocalFreq( eGateType eGate, int tstart, int tstop, int fWidth,
int whichScale )
    {
    int scaleBase = whichScale * columnSize;
    int outOffset = whichScale * numberOfTimes;
    char* eGateA = pGate + gateStride * eGate + outOffset;

    // Do full self product, but amalgamate by fWidth
    for ( int f1 = 1; f1 < columnSize-fWidth; f1 += fWidth ) {
        for ( int f2 = 1; f2 <= f1; f2 += fWidth ) {
            double sum = 0.0;
            for ( int t = tstart; t < tstop; t++ ) {
                if ( eGateA[ t ] ) {
                    float* p1 = getAddr( t, f1, scaleBase );
                    float* p2 = getAddr( t, f2, scaleBase );
                    for     ( int i = 0; i < fWidth; i++ ) {
                        sum += *p1++ * *p2++;
                    }
                }
            }
            put( sum );
        }
    }
}

// N = ( numberOfFreqs / fWidth ) **2
void CoincidenceRT::crossAddLocalFreq( int delta, int tstart, int tstop, int fWidth, int
whichScale )
    {
    int scaleBase = whichScale * columnSize;
```

FIG. 15H

```
        // Do full cross product, but amalgamate by 2s
        for ( int f1 = 1; f1 <= columnSize - fWidth; f1 += fWidth )
                {
                for ( int f2 = 1; f2 <= columnSize - fWidth; f2 += fWidth )
                        {
                        double sum = 0.0;
                        for ( int t = tstart; t < tstop; t++ )
                                {
                                float* p1 = getAddr( t+delta, f1, scaleBase );
                                float* p2 = getAddr( t, f2, scaleBase );
                                for ( int i = 0; i < fWidth; i++ )
                                        sum += *p1++ * *p2++;
                                }
                        put( sum );
                        }
                }
        }


void CoincidenceRT::crossAddLocalFreq( eGateType eGate, int delta, int tstart, int tstop,
int fWidth, int whichScale )
        {
        int scaleBase = whichScale * columnSize;
        int outOffset = whichScale * numberOfTimes;
        char* eGateA = pGate + gateStride * eGate + outOffset;

        // Do full cross product, but amalgamate by 2s
        for ( int f1 = 1; f1 <= columnSize - fWidth; f1 += fWidth ) {
                for ( int f2 = 1; f2 <= columnSize - fWidth; f2 += fWidth ) {
                        double sum = 0.0;
                        for ( int t = tstart; t < tstop; t++ ) {
                                if ( !eGateA[t] ) continue;

                                float* p1 = getAddr( t+delta, f1, scaleBase );
                                float* p2 = getAddr( t, f2, scaleBase );
                                for ( int i = 0; i < fWidth; i++ )
                                        sum += *p1++ * *p2++;
                                }
                        put( sum );
                        }
                }
        }
```

FIG. 15I